

MODIS Semi-Annual Report
Snow and Ice Project
Reporting Period: January - June 2003
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Summary

Much activity was undertaken during this reporting period. There was a focus on validation of the sea ice product, development of the fractional-snow cover enhancement to MOD10A1, coding of the albedo enhancement to MOD10A1 and coding of the sea ice global (4-km) product on the EASE-Grid. Details on the snow and ice algorithm validation are provided in the published literature (see papers, below) and on the website (<http://modis-snow-ice.gsfc.nasa.gov>). The reader is referred to the literature and website for up-to-date information. Lists of papers and presentations are provided below, and the contractor report follows.

Problems

Fourteen out of 20 of the band 6 detectors on the Aqua MODIS are not functional. Therefore we will have to develop an entirely new snow and sea ice algorithm for the Aqua MODIS. This is a significant problem because we need for the products on the Terra and Aqua satellites to be completely compatible in order to produce a climate-data record (CDR)-quality product. Preliminary work has begun attempting to replace band 6 with band 7 in the current snow and sea ice by reflectance algorithm and results look promising. However, the new preliminary algorithm must be tested in a variety of land covers before it can be implemented and validated.

Validation

Validation focused on the sea ice ice-surface temperature (IST) product during the last 6 months. The IST product is now validated to stage 1, with an accuracy of <1.7 K. Details of the validation have been written up for publication and are available on request (see Hall et al. paper, below, submitted to TGARS).

Peer-reviewed papers (in preparation, submitted, accepted and in press) from 2001 to the present:

Hall, D.K., J. Key, K. Casey, G.A. Riggs and D. Cavalieri, submitted, "Ice Surface Temperature Product from the Moderate-Resolution Imaging Spectroradiometer (MODIS)," *TGARS*.

Salomonson, V.V. and I.L. Appel, submitted: "Estimating Fractional Snow Cover from MODIS Using the Normalized Difference Snow Index (NDSI)," *Remote Sensing of Environment*.

Hall, D.K., G.A. Riggs, V.V. Salomonson, N.E. DiGirolamo and K.J. Bayr, 2002: "MODIS Snow-Cover Products," *Remote Sensing of Environment*, 83:181-194.

Hall, D.K., R.E.J. Kelly, G.A. Riggs, A.T.C. Chang and J.L. Foster, 2002: "Assessment of the Relative Accuracy of Hemispheric-Scale Snow-Cover Maps," *Annals of Glaciology*, 34:24-30.

Kaufman, Y.J., R.G. Kleidman, D.K. Hall, J.S. Barton and V.J. Martins, 2002: "Remote sensing of subpixel snow cover using 0.66 and 2.1 μm channels," *Geophysical Research Letters*, 28(16) .

Hall, D.K., G.A. Riggs, V.V. Salomonson and G.R. Scharfen, 2001: Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) Snow-Cover Maps, *Proceedings of the IAHS Hydrology 2000 Conference*, 2-8 April 2000, Santa Fe, NM, pp. 55-60.

Tait, A.B., J.S. Barton and D.K. Hall, 2001: A prototype MODIS-SSM/I Snow Mapping Method, *Proceedings of the IAHS Hydrology 2000 Conference*, 2-8 April 2000, Santa Fe, NM, pp. 139-141, 2001.

Tait, A.B., J. S. Barton, D.K. Hall, 2001: A prototype MODIS/SSM/I snow-mapping algorithm, *International Journal of Remote Sensing*, 22(17):3275-3284.

Hall, D.K., J.L. Foster, V.V. Salomonson, A.G. Klein and J.Y.L. Chien, 2001: "Development of a Technique to Assess Snow-Cover Mapping Errors from Space," *IEEE Transactions on Geoscience and Remote Sensing*, 39(2):432-438.

Proceedings papers and selected abstracts from 2001 to the present:

Hall, D.K., V.V. Salomonson, G.A. Riggs and A.G. Klein, 2003: "Snow and ice products from the Moderate Resolution Imaging Spectroradiometer," *Proceedings of the ASPRS meeting*, 5-9 May 2003, Anchorage, AK.

Hall, D.K., G.A. Riggs and V.V. Salomonson, 2003: "Mapping Global Snow Cover using Moderate Resolution Imaging Spectroradiometer (MODIS) data," *Glaciological Data Report*, NSIDC special report.

Hall, D.K., R. Solberg and G.A. Riggs, 2002: Validation of satellite snow cover maps in North America and Norway, *Proceedings of the 59th Eastern Snow Conference*, 5-7 June, 2002, Stowe, VT.

Riggs, G.A. and D.K. Hall: Reduction of cloud obscuration in the MODIS snow data product, *Presented at the 59th Eastern Snow Conference*, 5-7 June, 2002, Stowe, VT. [Note: an e-mail problem precluded publication of this paper but it is available on the website: <http://modis-snow-ice.gsfc.nasa.gov/publications.html>.]

Appel, I.L. and V.V. Salomonson, Estimate of fractional snow cover using MODIS data, IGRSS'02, 24-28 June 2002, Toronto, Canada.

Hall, D.K. and J.L. Foster, in press: Snow, *Our Changing Planet – A View from Space*, Cambridge University Press.

Hall, D.K., R.E.J. Kelly, A.T.C. Chang, J.L. Foster and J.Y.L. Chien, "Analysis of Relative Errors in Snow Maps in North America, Winter 2001-02," (abstract only), presented at Progress in Electromagnetics Research Symposium 2002 (PIERS 2002), Cambridge, MA, 1 July 2002.

D.K. Hall, V.V. Salomonson, G.A. Riggs and Janet Y.L. Chien, "Snow-Cover Variability in North America in the 2000-2001 Winter as Determined from MODIS Snow Products," Proceedings of IGARSS'01, 9 – 13 July 2001, Sydney, Australia, 2001.

R.E.J. Kelly, A.T.C. Chang, J.L. Foster and D.K. Hall, "Snow cover observations in north-east Asia using multi-sensor satellite imagery," *Proceedings of IGARSS'01*, 9 – 13 July 2001, Sydney, Australia, 2001.

Riggs, G.A., D. K. Hall, J. R. Key, in press: "Initial Evaluation of MODIS Sea Ice Observations," *Proceedings of the 58th Eastern Snow Conference*, 14-18 May 2001, Ottawa, Canada.

Hall, D.K., G.A. Riggs and V.V. Salomonson, 2001: "Analysis of a Time Series of Snow-Cover Maps of North America Derived from the Moderate Resolution Imaging Spectroradiometer Instrument," *Proceedings of the 58th Eastern Snow Conference*, 14-18 May 2001, Ottawa, Canada (Abstract only).

Barton, J.S., D.K. Hall and G.A. Riggs, 2001: "Fractional snow cover from the MODIS snow-mapping algorithm," Proceedings of the 57th Annual Eastern Snow Conference, 17-19 May 2000, Syracuse, NY.

MODIS-related presentations during the reporting period:

Hall, D.K., "Update on MODIS snow and ice product status and validation," MODLand meeting, 15 July 2003, Baltimore, MD.

Riggs, G.A., "Snow and ice products from the Moderate Resolution Imaging Spectroradiometer," poster presentation at the ASPRS meeting, 6 May 2003, Anchorage, AK.

Hall, D.K., "Remote Sensing Studies of Glaciers and Snow Cover," Polar Science Teacher Education Workshop, GSFC, Greenbelt, MD, April 25, 2003.

Hall, D.K., "MODIS snow and ice products useful for modeling," USDA/Hydrological Sciences Branch Retreat, 30 January 2003.

Hall, D.K., "Is the global snow and ice melting, or does it just seem like that from space?" Department of Environmental Science seminar series, Emory University, Atlanta, GA, 20 February 2003.

Contractor Report - Algorithm and Coding Work Accomplished During Reporting Period:

Contractors evaluated and analyzed Collection 4 MODIS cryospheric products from science test runs done in the MODAPS. Evaluations resulted in revisions being made in some of the algorithms. The final result was that all algorithms were approved for Collection 4 processing and reprocessing.

Monitored and evaluated Collection 4 data products from the forward and reprocessing MODAPS streams.

Comparison of MODIS Terra and Aqua snow and sea ice products was a focus of activity. Evaluated and investigated the impact of MODIS Aqua band 6 non-functional detectors on the snow and sea ice products and on the cloud mask product input to those algorithms. Preliminary investigation was conducted into the use of MODIS Aqua band 7 as a replacement for band 6 in which 70% of detectors are non-functional. Along with that the Aqua cloud mask product was evaluated for impacts of non-functional detectors. The revised Aqua cloud mask that uses band 7 in place of band 6 was evaluated for performance and impact to the Aqua snow and sea ice algorithms and data products.

Aqua MODIS products MYD10_L2 and MYD29 were released about 28 May 2003.

Investigated the Aqua band 6 non-functional detectors problem. Evaluated the impact of non-functional detectors on the snow algorithm and the cloud mask algorithm. Search and selection of swaths to use for in depth investigation was an important part of investigation. Analysis was applied to several MODIS Terra scenes to investigate the relationship between using band 6 and using band 7 in the NDSI. Software tools of ENVI and IDL were used in the investigation. Goal is to determine a new NDSI threshold for Aqua that will give a snow map very, very similar to Terra.

MOD10_L2

Monitored and evaluated Collection 4 data.

MOD10A1

A revised version of the algorithm that included calculation of snow albedo at 500m resolution and a new observation selection scoring algorithm was delivered to the project in April. Numerous improvements, major and minor were made to the algorithm and data product. Evaluation was conducted during development and test of the

revisions. Wrote and submitted the Product Change Request (PCR) for this version of MOD10A1. (A PCR is required for change in a product within a collection.) Worked with SDST to make some code fixes and revisions in the code during integration and testing process.

Slope and aspect data files from a collaborator were converted from a binary format to HDF. Slope/aspect files were generated for all tiles in Sinusoidal projection with land (327 files) for input to the MOD10A1 PGE. Updated BRDF files were also received and integrated into the PGE. Integrated updated BRDF data and updated albedo calculation equations. Additional data values were added to the snow albedo to flag locations where MODIS data and ancillary data do not match up or where data is out of bounds.

Integrated new procedure used to match up 500m and 1km data from input MODIS data products. This pixel to layer match up is used to determine which data is used to determine snow cover and to compute snow albedo. The procedure was translated into C language from its original IDL procedure form.

MOD10A2

Monitored and evaluated Collection 4 data.

MOD10C1

Investigated a problem encountered in Collection 4 science test processing. Determined the cause of the problems reported solution to SDST and modified the code to safeguard against this problem occurring in the future.

MOD10C2

Monitored and evaluated Collection 4 data.

MOD29

Monitored and evaluated Collection 4 data.

Intensive analysis of the ice surface temperature (IST) was done to support validation study of the IST.

MOD29A1

Delivered a fix for the daily sea ice (MOD29A1) algorithm. The problem was an algorithm failure with all night tiles that had only a single layer of data stored in them.

MOD29C1

Improvements were made to the beta version of the daily sea ice global CMG algorithm code. This algorithm is used in-house to produce days and time series of products for evaluation and for use in presentations.

Attended the biweekly status meetings of the MODLAND science data support and processing subgroup.

Participated in monthly teleconferences with NSIDC discussing status of MODIS cryospheric products and related issues.

User's guides for the snow and sea ice products and the snow albedo product were revised and posted on the project website (modis-snow-ice.gsfc.nasa.gov).

"What's New?" section of the project website (modis-snow-ice.gsfc.nasa.gov) was updated; SCF news briefs about changes in the ECS Collection 4 cryospheric data products and release of the products were included.

Created a research version of the swath snow algorithm (MOD10_L2) for testing of a fractional snow cover algorithm within the product.

Drafted and revised product quality description and validation status of the Collection 4 MODIS snow and sea ice products. Those revisions were posted to the LDOPE website. (The LDOPE website is linked to by the EDG for users to read the product quality information as part of the data ordering process.)

IDL procedures were written to support generation of composited images of the prototype daily sea ice data product (MOD29E1) including, sea ice extent and IST, to evaluate the affects of different compositing periods on reducing cloud obscuration.

Software tools were revised to enable better processing and image generation of MODIS direct broadcast data obtained from the UW SSEC site.

Improved on ability to generate true color images for posting to the project website and for use in presentations and publications.

Wrote IDL procedure to support investigation of relationship between MODIS Terra band 6 and band 7 relevant to snow mapping. Part of investigation into the use of MODIS Aqua band 7 in place of band 6 in which 70% of detectors are non-functional.

Created 'rules of discrimination' for extensive set of sea ice IST validation cases. Re-visited each data set, applied rules of discrimination to determine cases to be used in publication related material.

Put project website in compliance with new NASA/GSFC website policies and registry requirements. Tasks included;

- Registered website with NASA GSFC web registry.
- Corrected footer to conform to NASA logo policy.
- Added all required informational banners to introductory web page.
- Confirmed compliance with new log retention policy.
- Removed email addresses from html display.
- Added GSFC policy required meta tags to intro web page.
- Checked Section 508 compliance, made changes to ensure continued compliance.

In an effort to keep users updated, news, images and information were frequently posted to the project website. Types of information posted were; MODIS snow and sea ice images, showing seasonal events, news briefs, validation information, and revised publications (usually in PDF). Links to other websites were updated and added.

Evaluated website software in order to keep current with technology and improve efficiency in maintenance and revision of the website.

Facilitated Glacier Bay website ownership changes from Code 930 control to Code 970 control. Communicated with web server civil servant administrator regarding continued hosting of Glacier Bay website. Assisted the ATR with technical details of web hosting and web site maintenance topics.

Searched for and ordered MODIS sea ice data in support of an aircraft field campaign (13-22 March 2003) over Alaska for a collaborative investigator to use in support of validation.

Gathered several JCAD-5 data sets, analyzed data in support of sea ice surface temperature validation work. Created JCAD-4; JCAD-5; Prudhoe Bay, AK; Nome, AK scatter plot of observed temperature (MODIS IST) vs. retrieved temperature (buoy or NOAA tide station). Applied linear regression fits to data for analysis.